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THE VESTIBULAR APPARATUS UNDER WATER AND IN COMPRESSED GAS ENVIRONMENTS: ABSTRACTS OF TRANSLATED STUDIES

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13 ABSTRACT

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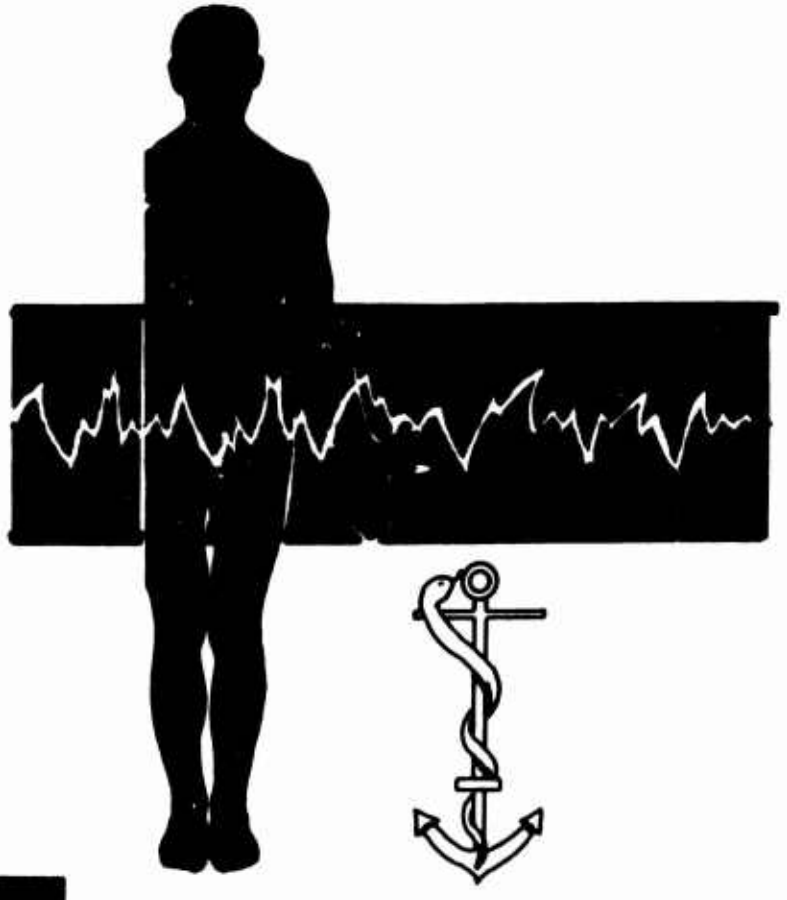

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THE VESTIBULAR APPARATUS UNDER WATER AND IN COMPRESSED GAS ENVIRONMENTS: ABSTRACTS OF TRANSLATED STUDIES

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THE VESTIBULAR APPARATUS UNDER WATER AND IN COMPRESSED GAS ENVIRONMENTS: ABSTRACTS OF TRANSLATED STUDIES

Robert S. Kennedy

Abstract. Twenty-two studies which contribute to our understanding of the role of the vestibular system under water and high pressure are abstracted in this report. Several aspects of vestibular function are included (e.g. decompression sickness, pressure vertigo, diver navigation, etc.). The studies were originally published in German (in one case, Russian), but have been translated into English. Copies of the full translations are available on request from the author of this report.

Key Words. Vestibular functions; diving medicine; vestibular decompression sickness; translation; decompression sickness; equilibrium; vertigo; labyrinth; caisson disease; vestibular hits; Type II DCS; diver navigation.

INTRODUCTION

In the course of studying the various relationships of the human vestibular apparatus to the undersea environment, it became apparent that this organ complex had not always received as much attention as it should. To remedy this neglect, a series of studies were undertaken at the Naval Medical Research Institute. These studies have reported the following: (a) in the older caisson literature, vestibular symptomatology was often mentioned, although these findings tended not to be recognized in reports by the more modern (1930-1960) diving investigators (Kennedy 1974); (b) in addition to decompression sickness, the vestibular system

is implicated in the high pressure nervous system syndrome, pressure vertigo, disorientation, swimmer navigation, and other problems of the working diver (Kennedy 1973); (c) vestibular decompression sickness is the next largest symptom complex after joint pain (Kennedy and Diachenko 1974); (d) positive function of the vestibular apparatus, as revealed by caloric irrigation, produced higher thresholds in a group of experienced Navy divers than in a control group (Kennedy and Fregly, in preparation; and (e) nearly 1,000 references were collected which it was felt were relevant in one way or another for an understanding of the role of the vestibular system in diving (Kennedy 1972).

An increased interest in the vestibular apparatus has occurred within the past 10 years (Kennedy 1972) and several recent studies have reported vestibular implications in compressed gas environments (Edmonds 1971; Rozsahegyi 1959; Rubenstein and Summitt 1971; McCormick, Higgins, Clayton, and Braver 1971; Farmer and Thomas 1973).

In connection with assembling the bibliography (Kennedy 1972), which attempted to address all of the roles of the vestibular apparatus under water and compressed gas, several studies published in German were translated. These studies include reports of the older literature concerning decompression sickness, studies of the vestibular system in general, and studies related to the use of the vestibular system as a diver navigation aid. It appears that these studies have not been absorbed within the scientific literature written in English. For this reason, and because of the recent increased interest in these problems, it was felt that a review of the translated material was needed. The purpose of the present

report is to describe the contents of each of these studies and to announce the availability of photocopies of the full translations.

The reports which deal with decompression sickness (Abstracts 1 through 12) have been arranged chronologically. Abstracts 13 through 22 deal with other aspects of the vestibular system in diving. The abstracts include some interpretations of the relevance of each study for modern Navy diving medicine.

When requesting photocopies, please indicate the full title of the paper(s) requested, and indicate whether all or part of the German copy is desired also.

Requests for photocopies should be sent to:

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REFERENCES CITED IN INTRODUCTION

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Farmer, J.C., and W. G. Thomas. Vestibular injury during diving. Försvarsmedicin 9(3):396-403.

Kennedy, R. S. 1972. A bibliography of the role of the vestibular apparatus under water and pressure; Content-oriented and annotated. U.S. Naval Medical Research Institute, Bethesda, Md. AD750686.

Kennedy, R. S. 1973. The role of the vestibular apparatus under water and high pressure. U.S. Naval Medical Research Institute, Bethesda, Md. AD761616.

Kennedy, R. S. 1974. General history of vestibular disorders in diving. Undersea Biomed. Res. 1(1):73-81.

Kennedy, R. S., and J. A. Diachenko. (in press) The incidence of vestibular symptomatology in 2,500 U.S. Navy Diving accidents (1933-1970). Aerosp. Med.

McCormick, J. G., T. L. Higgins, R. M. Clayton, and R. W. Brauer. 1971. Auditory and vestibular effects of helium-oxygen hyperbaric chamber dives to convulsion depths. 82nd Meeting of the Acoustical Society of America, Denver, Colo., 19-22 October.

Rozsahegyi, I. 1959. Late consequences of the neurological forms of decompression sickness. Br. J. Ind. Med. 16:311-317.

Rubenstein, C. J., and J. K. Summitt. 1971. Vestibular derangement in decompression. Pages 287-293 in C. J. Lambertsen, ed. Underwater physiology. Academic Press, New York.

ABSTRACTS OF AVAILABLE TRANSLATIONS

1. HELLER, R., W. MAGER, and H. von SCHROTTER.
Vorlaeufige Mittheilung ueber Caissonarbeiter. (Introductory report on caisson workers. Trans. by Mrs. A. Woke, NMRI, 1972.)
Wien Klin. Wochenschr. 8:475-476, 1895.

Heller and associates provided the medical coverage for the caisson works at Nussdorf prior to the turn of the century. Essentially, no problems were encountered until 1.5 ATA were reached.

The time course and symptoms of decompression sickness encountered on the project are described. Generally, symptoms occurred 15 minutes to 1 hour after leaving the caisson and involved extreme pain in the lower extremities; occasionally the ears were affected, and respiratory difficulties were noted.

The authors then describe the symptoms within a few main groups: (a) the auditory organ; (b) in the extremities; (c) swelling-type symptoms; (d) loss of consciousness.

2. ALT, F.
Ueber apoplectiforme Labyrintherkrankungen bei Caissonarbeitern. (Concerning apoplectic-form labyrinth diseases in caisson workers. Trans. by Mrs. A. Woke, NMRI, 1971.).
Monatsschrift fuer Ohrenheilkunde 30:341-349, 1896.

In this paper Alt is reporting some of the same experiences (Nussdorf flood gate at the Danube) which were published later (1900) in a two-volume book by Heller, Mager, and von Schrotter; however, since the book has not been translated, this paper may represent the best source for these data.

Although the full account of all symptoms may appear elsewhere, Alt feels that the large number of ear diseases discovered warrants a separate

detailed discussion. In this paper, he limits himself to apoplectic-form labyrinth diseases.

Alt reviews the previous literature including Russian, French, and English experiences. It is considered meager. He then lists three case histories in great detail. Sudden deafness and vestibular symptomatology are described throughout and the time courses of the diseases are recounted.

The author appears to feel that the problems of decompression sickness are due to hemorrhage within the labyrinth or at least vascular blockage of some sort.

He then reports on studies conducted in dogs and in rabbits.

3. HOCHE, A.
Ueber die Luftdruckerkrankungen des Centralnervensystems. (Air pressure diseases of the central nervous system. Trans. by Mrs. A. Woke, NMRI, 1972.)
Berlin. Klin. Wochenschr. 22:464-469, 1897.

The author reviews the principle of the caisson and explains the use of caissons in bridge building prior to the turn of the century. He then lists some case histories of workers who suffered decompression sickness. The first individual was noted as having positional nystagmus and other cases as having pain in the ears. Two cases where there is a suspicion of spinal lesions are presented.

Hoche then reviews the work of van Rensselaer and criticizes van Rensselaer's reporting of names and numbers, but finds the study otherwise generally useful, particularly with regard to the description of microscopic investigations. He also recounts P. Bert's first real encounter with decompression sickness.

Hoche also makes the point that Bert's theory regarding nitrogen bubbles as the chief cause of decompression sickness is correct and is preferred to the notion held by many in England and America that it is due to blood fill in the central organs which cause "congestion."

He goes on to describe how bubbles may be formed and why some persons report peripheral and others central nervous system symptoms; in addition, he discusses why certain portions of the spinal cord are susceptible to this sort of injury and why other portions are spared.

The author concludes with a summary of the released gas theory of decompression sickness and concludes that the more gas released, the more severe the symptoms. Also, he feels that the gas is carried embolically in bubbles into the central nervous system where it produces ischemic softening by closure of the end arteries. He believes that tissue destruction by released bubbles plays a secondary role.

4. ALT, F., R. HELLER, W. MAGER, and H. von SCHROTTER.
Pathologie der Luftdruckerkrankungen des Gehoerorgans. (Pathology of air pressure diseases of the auditory organs. Trans. by Mrs. A. Woke, NMRI, 1972.)
Monatsschrift fuer Ohrenheikunde 31:229-242, 1897.

Bridge building, diving, and flying all occasion abrupt pressure changes. These pressure changes have several bad "effects" on humans, but little documentation (to the date of this paper--1897) has appeared concerning damage to the auditory system from these pressure changes, although they are known to occur. The bridge at Nussdorf near Vienna offered an opportunity to study these problems.

Pressure changes which produce pain and other symptoms due to the inability to clear the ears are described. The acoustical engineering of

chambers and caissons and the several auditory changes which result are listed. The authors feel that decompression presents fewer problems than compression. They believe that auditory problems are due to two factors: first, the unequal pressure inside versus outside the auditory system; and second, diseases caused by gas emboli after rapid decompression. They then follow with a description of the various symptomatology which may be caused or aggravated by compression (e.g. inability to clear the ears by Valsalva, barotraumatic otitis media) and from decompression (lesions in the semicircular canals and cochlea are actually shown in Figure 1).

The following symptoms are known: dizziness, humming, vomiting, unconsciousness, and often sudden deafness. Other symptoms include reeling from side to side and dizziness when standing with eyes closed.

The authors conclude with the description of an experiment on guinea pigs where histology performed on the labyrinth is presented.

5. von SCHROTTER, H.
Zur Pathogenese der sogenannten Taucherlaehmung. (The pathogenesis of so-called diver paralysis. Trans. by Mrs. A. Woke, NMRI, 1972.)
Verhandlungen der deutschen pathologischen Gesellschaft 3:136-138, 1904.

The author reiterates his opinion that the paralysis which occurs after rapid decompression is due to the release of bubbles into the circulation and not to hemorrhage or bursting blood vessels, as others have suggested. Until now, these opinions have been based on animal studies. Von Schrotter then reports on two humans who died: the first reported dizziness, became unconscious, and died 48 days later. Postmortem slides of the spinal cord are shown and described. Lesions are present. The

second case resembles the first. Other central nervous system damage is described.

A short discussion follows.

6. STIGLER, R.
Versuche ueber die Beteiligung der Schwereempfindung an der Orientierung des Menschen im Raume. (Experiments dealing with the participation of the sensation of gravity in the orientation of man in space. Trans. by Mrs. A. Woke, NMRI, 1972.)
Archiv. fuer die gesamte Physiologie 148:573-584, 1912.

In this early article the available information regarding orientation in space from other than visual and contact cues is reviewed and it is concluded that another sense system should be postulated, viz., an internal position sense. The author compares the specific gravity of water to the specific gravity of the body under various conditions (e.g. inspiration-expiration, increased pressure, etc.).

The literature concerning position sense in water is reviewed, particularly the work of Exner, James, and Nagel, where conflicting results appear to exist. The author set out to extend these findings by immersing swimmers who were blindfolded and also had their ears covered. The subjects were rotated underwater for 1 to 1½ minutes and then asked to indicate which way was up. In general, the subjects were unable to determine the upright and became very anxious about their poor performance. Anecdotal evidence in support of these findings is also presented.

A second experiment was then conducted with subjects in diving rigs to minimize the possible effects associated with a long period of breath-holding. These subjects were also qualified divers. The results showed that the subjects generally were able to indicate up correctly, although

errors were reported. Some subjects were better than others and individual narrations are presented.

The author concluded there is an ability to determine the upright underwater, although problems ensue during periods of increased attention elsewhere. These data convinced Stigler that a position sense exists over and above what the skin provides.

7. CHAROUSEK, H.
Zur Mechanik des Drucksymptoms. (The mechanics of pressure symptoms. Trans. by Mrs. A. Woke, NMRI, 1972.)
Z. Hals-, Nasen- Ohrenheilkd. 15:225-227, 1926.

The manner by which pressure may be transduced throughout the ear from external to internal, and the converse, is discussed and diagrammed.

8. KOMENDANTOV, G. L.
Vestibular nystagmus in conditions of lowering barometric pressure. Page 53 in The functioning of organisms under conditions of changing gaseous environments. Moscow, Leningrad: Academy of Sciences, USSR, 1955. (In Russian, trans. by J. Diachenko, NMRI, 1972.)

The author discusses several measures of the positive functioning of the nonauditory labyrinth and its pathways, viz., post-rotational nystagmus, galvanic nystagmus, caloric nystagmus, righting reflexes, head positioning, positional nystagmus, preparatory reflex, and post-rotational head nystagmus.

Previous investigations have shown that these reflexes remain relatively unchanged at altitudes between 15,000 and 22,000 feet and become slightly weaker between 24,000 and 30,000 feet. The present study examined the post-rotational nystagmus in rabbits induced by angular acceleration (10 revolutions in 20 seconds). The results showed that the reflex remained intact through 16,000 feet, but fell off

at about 30,000 feet. Nystagmus frequency appeared to decrease at 16,000 feet compared with baseline, and then increase again at 19,000 to 30,000 ft.

9. ROZSAHEGYI, I., AND B. GOMORI.
Otologische Untersuchungen bei Caissonarbeitern. (Otological investigations on caisson workers. Trans. by Mrs. A. Woke, NMRI, 1972.) Arch. Gerwerbepathol. Gewerbehyg. 18:384-393, 1961.

The authors consider that Meniere-type syndromes are the next most frequent symptoms of decompression sickness after joint pain. They review the literature which tends to support this belief.

They then compare the positive functions of the vestibular and auditory systems in two groups of caisson workers: those who had experienced symptoms of decompression sickness, and a control group of persons who had had no symptoms. The authors claim that persons exposed to high noise conditions were excluded, but do not comment on the high noise levels probably experienced in caissons.

Pure tone threshold audiograms and caloric tests were administered.

The results appear clear cut: half again as many hearing losses were seen in the decompression sickness group (i.e., 71% vs. 48%) and twice as many vestibular deficits (38% vs. 18%). Further, 50% of the control group was normal on both tests although only 20% of the decompression sickness group showed normal auditory and vestibular responses.

The authors then speculate on the various suspected etiologies and compare the incidences of auditory and vestibular difficulties.

The authors point out that presbycusis and noise probably did not contribute significantly to the high incidence of hearing loss since the control group was younger and had longer caisson exposures than the decompression sickness group.

10. von WILKE, M., and STEFFEL, M.
Hoerstoerungen bei Tauchsportlern (Disturbances in hearing of sport divers. Trans. by D. P. Hansen, NAVMISCEN, 1974.)
Zeitschrift das Deutsche Gesundheitswesen 20:1149-1156, 1965.

The authors present otologic exams of 47 divers, 20 of whom experienced vestibular or auditory ailments in connection with diving. Many of the audiograms shown contain evidence of a hearing loss at 4,000 and 6,000 Hz. The incidences for this population were 19 of 47 with 7 found in the right ear, 4 in the left, and 8 bilateral. This finding does not agree with that of Lang, Rozsahegyi, and Tarnoczy (1971) abstracted later in this report.

In addition to presenting six audiograms, the authors summarize the 20 case histories in tabular form. They go on to emphasize that in 19 of 47 divers, this distinct damage which was present appeared to be progressive yet was noticed by only 2 of the 19 persons.

11. von WAGEMANN, W.
Barotrauma und Taucherkrankheiten (Barotrauma and diver diseases. Trans. by D. P. Hansen, NAVMISCEN, 1974.)
Z. Laryngol. Rhinol. Otol. 45:379-383, 1966.

Barotrauma is discussed from the standpoint of its relationships to the diver and diving problems. The symptomatology is described as well as prophylaxis and therapy. The author lists six graded measures of Eustachian tube function as an index of the fitness of the individual for diving. He suggests that a score from 4 to 5 is necessary for considering the patient fit.

12. LEHMANN, H. J., K. HELD, and G. WERNER.
Neurologische Folgezustaende der Taucherkrankheit. (Neurological conditions resulting from diver's disease. Trans. by Mrs. A. Woke, NMRI, 1972.)
Nervenarzt 41:189-193, 1970.

The authors briefly review the literature concerning central nervous system problems in divers. They cite recent evidence that progressive encephalomyelopathy can result from acute decompression sickness. This finding contradicts the early studies of Heller, Mager, and von Schrotter (1900) who felt that the disease was not progressive.

The authors examined 23 professional divers who had had an acute diving accident and compared them to a control group (23 seamen who had performed similar work, but were not divers). For nearly all comparisons, the diver group showed a greater incidence (in general, twice the frequency of neurological symptoms). Specifically, gaze nystagmus, standing steadiness, blind walk deviation, ataxia, hearing difficulties, etc., occurred in 50% or more of the divers, and 25% or less of the control group. Additionally, EEG changes were not found, although aseptic bone necrosis was seen in all but one of the divers.

These authors found no evidence for progressive degeneration of the neurological symptoms, although there was no recovery either.

13. LANGE, J., I. ROZSAHEGYI, and T. TARNOCZY.
Kochleovestibulaere Befunde bei Caissonarbeitern. (Cochleovestibular conditions in caisson workers. Trans. by Mrs. A. Woke, NMRI, 1971.)
Monatsschr. Ohrenheilkd. Laryngo-Rhinol. Reprint 1, 1971.

The authors briefly review the history of compressed gas work and report on their experiences with the workers on the Budapest Subway. They tested 432 subjects, generally under 40 years of age, and otherwise healthy.

The environmental conditions in the caisson during acoustic and vestibular testing were 2-2.2 ATA, 25° C, and 90% relative humidity. Noise levels were between 108 and 120 dB. Audiograms and calorics as well as positional and rotational tests were performed.

The results showed a greater incidence of hearing loss than one would expect from the noise levels, and left ear problems were more frequent. The authors speculate on the causes of these problems and, in general, offer a blood-flow hypothesis. Additionally, differences in blood vessel diameter and thus blood transport on the left versus right side (the latter being superior) are offered as evidence for the right-left difference.

The authors comment on vestibular cases, particularly in persons who also experience cranial trauma, but provide no data. They reference another of their studies, not yet published, where data may be found. They attribute vestibular problems to brain stem lesions.

14. GULDBERG, F. O.
Die Cirkularbewegung als thierische Grundbewegung, ihre Ursache, Phaenomenalitaet und Bedeutung. (The circular movement as the basic movement of animals, its cause, phenomenon, and importance. Trans. by Mrs. A. Woke, NMRI, 1972.)
Z. Biol. (Munich) 35:419-458, 1897.

This study was prompted by the observation that herds or families of animals find each other with great ease after separation. Other observations showed that paths taken by young animals when they leave the brood, clutch, etc., are generally ring-like or circular. As animals get older, other senses come into play and the locale is recognized, sound are heard, and so on; but in the young, circular movements appear to predominate.

In order to submit these observations to test, the author prevented animals (dogs, rabbits, mice, pigeons, ducks, swallows, and trout) from using sight, hearing, and smell. The difficulties associated with getting animals moved under these restrictions are discussed. The findings show that when they moved they did so in a circle, although the direction of turning and the diameter of the circle, while consistent within an animal, was not consistent across animals or species.

When humans were tested, the same findings were obtained, although spiral movement was seen when the subjects walked faster.

Guldberg hypothesized that some asymmetry of the organism's body was reponsible. He convinced himself of the veracity of his hypothesis by measurements that he took, but he reported no data.

The author also reports on anecdotal evidence obtained with humans during snowstorms on lakes.

15. RETZIUS, G.
Ueber die Endigungsweise des Gehoernerven in den Maculae und Cristae Acusticae im Gehoerlabyrinth der Wirbeltiere. (The manner of termination of the auditory nerve in the maculae and cristae acusticae in the auditory labyrinth of vertebrates. Trans. by Mrs. A. Woke, NMRI, 1972.)
Biologische Untersuchungen (Stockholm) NF 12, 1905, p. 1-12.

The purpose of the paper is to summarize the state of knowledge available at the time (1905) relative to the type of terminations of the auditory nerve. The author reviews his earlier work where he showed that the epithelium of the maculae and the cristae consist of two types of cells: the long fiber cells of Max Schultze and the bottle-like auditory hairs which Retzius notes consist of a number of parallel lying fibers, not as had been thought, a simple hair. Their form is then described as is

the author's work on the bone fish, published in 1872. The work in fish of von Exner, Meyer, Kuhn, Cison--all published prior to 1880, is also discussed. Following this, the work of Ramon y Cajal is quoted wherein his new silver method is described along with the auditory nerve fiber terminations which are evident with the new method.

The author concludes that hair cells are the only end organs of the auditory nerve. He then follows with a long description of the various terminations on man, rabbit, cat, frog, and chicken embryo, dealing particularly with the nerve fibers which emerge from the macula and cristae acusticae. He compares his findings to the work of others: generally supportive when compared to the work of Ramon y Cajal and innovative when compared to others. The author concludes with a description of the two types of nerve endings in the crista: (a) those with a beaker or cup formation serving 1-5 hair cells and (b) those which have finer fibers. Apparently, it was not until the Cajal silver method of staining was developed that these nerve endings could be differentiated.

16. BARANY, R.
Untersuchungen ueber den vom Vestibular-Apparat des Ohres reflektorisch ausgeloesten rhythmischen Nystagmus und seine Begleiterscheinungen. (Investigations on vestibular apparatus of the ear, reflectively released rhythmic nystagmus and its accompanying symptoms. Trans. by Mrs. A. Woke, NMRI, 1970.)
Berlin: Verlag Von Ascar Coblentz, 1906.

The author lists the difficulties associated with study of the vestibular system, particularly the lack of conscious awareness of the sensation. In order to experience these sensations, he suggests caloric irrigation, stopping after passive movement and galvanic stimulation. He calls

attention to the fact that when the eyes are closed, the sensation in the nystagmus is suppressed and so is the feeling of turning. Barany concludes that nystagmus must be present for the sensation to enter consciousness.

The difficulties associated with subjective reports of apparent movement following vestibular stimulation are described and it is concluded that since the eye movements are probably reflecting the movement of the endolymph, they should be studied as the indicator methodology of vestibular stimulation. This is especially true since the nystagmus eye movements can occur unconsciously and are particularly useful in the study of disease; clinical examples are offered and references to other work with normals as well as labyrinthine defectives and persons with cerebellar disturbances, and so forth.

Caustions regarding untoward side effects of caloric stimulation are listed.

17. ABDERHALDEN, E.
Beobachtungen zur Frage der morphologischen und funktionellen Asymmetrie des menschlichen Koerpers. (Observations concerning the question of the morphological and functional asymmetry of the human body. Trans. by Mrs. A. Woke, NMRI, 1971.)
Pfluegers Archiv fuer die gesamte Physiologie 177:213-216, 1919.

The author studied the directional preponderance exhibited by students who were ascending symmetrical left and right staircases. Most students used the right stairway, although the difference was smaller during overcrowding periods. Left-handed persons tended to use the left; no sex differences were observed.

There were essentially no differences in predisposition on leaving: left and right being equally chosen for descent.

18. ROORDA, P.
Der Einfluss der Drehung auf den Zeigeversuch von Barany. (The influence of turning on the pointing test of Barany. Trans. by Mrs. A. Woke, NMRI, 1971.)
Archives fuer Ohren, Hals-und Kehlkopfheilkunde 113:97-102, 1925.

The author reviews the early work of Barany with this test as well as the studies of Benjamin and of Nolan. Past pointing in connection with rotation provided discrepant results depending on the method employed. The author's purpose was to replicate with a more precise test and the subject was permitted more time to make his determination.

His findings show that in 2/3 of his 52 cases following rotation to the right, both arms deviate to the right, and the opposite effect occurs after rotation to the left. The remaining cases are then discussed for their potential diagnostic implications.

19. VYSLONZIL, E.
Ueber eine umschriebene Ansammlung von Otoconien im hinteren haeutigen Bogengang. (A transcribed accumulation of otoconia at the posterior membranous semicircular canal. Trans. by Mrs. A. Woke, NMRI, 1972.)
Monatsschr. Ohrenheilkd. Laryngo-Rhinol. 97:63-68, 1963.

The occurrence of a globular formation at the posterior semicircular canal near the common pillar is reported. The author found this change in three cases of severe nephrogenous hypertonia and in one case of lupus erythematodes. It was found that large masses of otoconia build up this globe, whereby layers of albumin traverse this formation and simultaneously appear to represent the connective mass. The pathogenesis of otoconia migration and masses of albumin is discussed, as well as the apparently glandular formation at this location of the semicircular canal. This article should be compared with one on cupulolithiasis by Schuknecht (1969) referenced in Kennedy (1972).

20. WUSTROW, F. and M. WESTHUES-KOELN.
Druckmessungen im Perilymphraum des horizontalen Bogengangs des Menschen bei der Rotation. (Pressure measurements in the perilymphspace of the horizontal semicircular canal of man at rotation. Trans. by Mrs. A. Woke, NMRI.)
Arch. Ohren. Nasen. Kehlkopfheilk. 185:652-655, 1965.

To study better whether pressure changes occur in connection with stimulation of the semicircular canals a manometer with the ability to register small pressures is required. The authors describe the device of Hamacher which has been used by pharmacologists for other purposes. The procedure for measurement of pressure changes in the perilymphspace using this device is described.

In a preparation, they then show that pressure changes in the perilymph do occur under angular acceleration and the response appears monotonic to the stimulus. The authors speculate that similar changes probably occur in the endolymph.

21. KORNHUMER, H. H.
Neurologie des Kleinhirns. (Neurology of the cerebellum. Trans. by Mrs. A. Woke, NMRI, 1972.)
Z. Gesamte Neurol. Psychiat. 191:13, 1968.

The old structure in archi- or vestbulo-, paleo- or spino-, and neo- or pontocerebellum is still useful for clinical orientation. Superior- and inferior-vermiform processes belong to the spinocerebellum. Both work together to maintain equilibrium and body posture. Lesions produce disturbances in equilibrium. The inferior vermiform process is also connected with position nystagmus. The middle vermiform parts, especially folium and tuber vermus, have a special function: apparently they serve the visual motor field. The anatomically found somatotopic structure of the superior vermiform process is clinically important.

22. SCHLICHTE, H. J. and K. SCHMIDT-KOENIG.
Zum Heimfindevermoegen der Brieftaube. (The home-recallability of the carrier pigeon. Trans. by Mrs. A. Woke, NMRI, 1971)
Die Naturwissenschaften 6:329-330, 1971.

In previous studies of homing pigeons, landmarks, and other visible data were generally available; however, new developments in contact lens technology permitted this experiment.

Clear red and blue filters produced no differences from control conditions, although cloudy lenses disrupted performance. For the latter conditions, the poor performance tended to be in the landing and recovery stage ($P < .0001$); take off, heading, and flight speed showed no differences with control groups.